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Analysis of Sobel Edge Detection Technique for Face Recognition

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Abstract- Edge detection refers to the process of identifying and locating sharp discontinuities in an image. Edge detection plays a vital role in image analysis and it is the key of solving many complex problems. Edge detection is an important preprocessing step for any image processing application and object recognition. Edge detection is very much difficult in noisy images, since both the noise and the edges contain high frequency content. In this paper, Sobel edge detection technique has been used to extract the edges from facial images which are used to detect face. In this paper, Sobel edge detection technique and its simulation results are discussed.

Index Terms- **Digital Image Processing, Edge Detection, Face Recognition, Sobel, Steps in Edge Detection.**

I. INTRODUCTION

Digital image processing refers to processing of digital images by means of a digital computer. Digital image consists of a finite number of elements, each of which has a particular location and value. These elements are called picture elements, image elements and pixels. Pixel is a term widely used to describe the elements of a digital image. It is a technology widely used for Digital image operations like feature extraction, pattern recognition, image segmentation and image morphology etc. The main goal of digital image processing is to improve the pictorial information. Digital Image Processing has become functional as well as popular research area in different fields such as astronomy, medical imaging, pattern recognition and video processing[1].

Face recognition is defined as the process of automatically identifying and verifying a person from a digital image. Face recognition has been very challenging and interesting area in real time applications. For face recognition, we first detect the face and then we compare it with a set of known individuals present in a database to verify the identity of the person. The concept of face recognition can be further extended to various biometric applications including fingerprint, Iris and voice recognition. Face recognition techniques can be classified into two basic approaches i.e. Feature based approach in which we analyze the features depends on their relationships and Holistic approach which deals with eigenfaces and neural networks. In Feature based approach, firstly we preprocesses the input image to remove the noise, and then we extract different facial features such as the eyes, mouth, nose, etc. and then computes the geometric relationships among these facial points and reduces the input facial image to a vector of geometric features[9].

Face recognition is one such important application in which edge detection plays a important role. Computer based face recognition systems are useful for security applications. It is a widely researched topic as facial features provide unique biometric identification for users. Face recognition systems are based on object recognition and tracking technologies. Face recognition is a difficult problem because of the generally similar shape of faces combined with lot of variations between images of same face. Generally image of a face changes with facial expression, age, illumination conditions and noise. There are three main approaches that deals with image variations that are due to the illumination changes. These approaches are used by general object recognition systems and the systems that are specific to faces. The first approach uses the gray-level information to extract the three dimensional shape of the object. The second approach is based on representations of the image and the stored model that are relatively insensitive to illumination changes. The third approach is to handle image variations that are due to the illumination changes by using as a model of different images of the same face taken under different illumination conditions[2].

II. EDGE DETECTION

Edge detection is one of the most frequently used techniques in digital image processing. Edge detection is an important preprocessing step for any image processing application and object recognition. Its application area reaches from astronomy to medical field. Edge detection significantly reduces the amount of data and filters out useless information, while preserves the important structural properties in an image. Basically edge is a boundary between two homogenous regions. In noise free images, edge detection is very helpful. But edge detection is a challenging task in noisy images. These noisy images are corrupted images, their parameters are difficult to analyze and detect. An edge detector can be used for improving the performance of a blurred image. Edge

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detection has applications in computer vision and security monitoring[10].

Edge basically consists of meaningful information and features. An edge is the boundary between an object and the background. The most important aspect of most of the edge detectors is to determine some boundary information in an image that represents image's interior objects. Edges characterize boundaries and therefore a problem of fundamental importance in image processing. Generally, an edge is defined as the borderline pixels that connect two mutually exclusive regions which differ in their luminance values. Consequently, the determination of an edge is based on some characteristics that are amplitude, location and orientation of a region[11].

A large number of edge detection operators are available, each of which are designed to be sensitive to various types of edges. Variables that are involved in the selection of sensitive edge detection operator are:

- **Edge Orientation:** The geometry of the edge detection operator determines a characteristic direction in which it is most sensitive to edges. Edge detection operator can be optimized to look horizontal, vertical or diagonal edges.
- **Noise Environment**: Edge detection is much difficult in noisy images. Because both noise and edges contain high frequency content, that attempts to reduce the noise results in blurred and distorted edges. Edge detection operators used on noisy images are larger in scope, so they can have enough data to reduce localized noisy pixels and results in less accurate localization of detected edges.
- **Edge Structure:** All the edges are not involved a step change in intensity. Effects like refraction or poor focus can result in objects with boundaries that are defined by small change in intensity. The edge detection operator must be responsive to such small change, so we do not have problems of false edge detection, missing the true edges, localization of edges and high computational time [3].

A. Principle of Edge Detection

In digital image, edge is a collection of the pixels whose gray value has a step change, It also refers to the part where the brightness of the image local area changes. In a small buffer area, a gray value rapidly changes to another whose gray value is very different with it. Edge generally exists between objects and backgrounds. The edge of an object is reflected in the discontinuity of the gray. The purpose of edge detection is to simplify the image data in order to minimize the amount of data that is to be processed. This method is used to refer as local operator edge detection method. Edge detection is mainly the measurement, detection and location of the changes in image gray. Image edge is the most basic features of the image. When we observe the objects, we see firstly the thing is edge and the line. Due to the composition of the edge we can understand the object structure. Therefore, edge detection is an important technique in graphics processing and feature extraction[5].

The basic idea of edge detection is as follows: Firstly use edge enhancement operator to highlighted the local edge of the image. Then, define the pixel "edge strength" and set the threshold to extract the edge point set. However, because of the noise and the blurred image, the edge detected may not be continuous.

B. Steps in Edge Detection

- **Filtering:** Some major classical edge detectors work fine with high quality pictures, but often they are not good enough for noisy pictures. Because they cannot distinguish edges of different significance. Noise is unpredictable contamination on the original image. There are various kinds of noise, but the most widely studied two kinds are white noise and "salt and pepper" noise. In salt and pepper noise, pixels in the image are very different in color or intensity from their surrounding pixels; the defining characteristic is that the value of a noisy pixel bears no relation to the color of surrounding pixels. Generally this type of noise will only affect a small number of image pixels. When viewed, the image contains dark and white dots, hence the term "salt and pepper" noise. In Gaussian noise, each pixel in the image will be changed from its original value by a small amount[4].

- **Enhancement:** Digital image enhancement techniques are concerned with improving the quality of the digital image. The principal objective of enhancement techniques is to produce an image which is better and more suitable than the original image for a specific application. Linear filters have been used to solve many image enhancement problems. Throughout the history of image processing, linear operators have been the dominating filter class. Not all image sharpening problems can be satisfactorily addressed through the use of linear filters. There is a need for nonlinear geometric approaches, and selectively in image sharpening is the key to its success. A powerful nonlinear methodology that can successfully address the image sharpening problem is mathematical morphology[6].

- **Detection:** Some points in image have a non zero value for the gradient and not all of these points are edges for a specific application. Detection is generally used to determine which points are edge points and which are not.

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There are different ways to perform edge detection. There are two major categories:

- **Gradient:** The gradient method detects the edges by taking maximum and minimum in the first derivative of the image. Gradient edge detectors measures the gradient of the image along two orthogonal axes. Gradient method of edge detection is the best for abrupt discontinuities. The edge detectors contain classical operators and uses first directional derivative operation[12].
- **Laplacian of Gaussian:** As Laplacian operator may detect edges as well as noise, it may be desirable to smooth the image first by convolution with a Gaussian kernel. This algorithm is not used frequently in machine vision [7]. Steps involved in laplacian of Gaussian method are as follows:

Step 1: Smoothing is done with Gaussian filter.
Step 2: Detection is based on zero crossings.
Step 3: Edge location.

The laplacian method searches for zero crossing in the second derivative of the image to find edges. The laplacian of 2-D function f(x,y) is a second order derivative defined as,

$$\nabla^2 f = \frac{\partial^2 f}{\partial x^2} + \frac{\partial^2 f}{\partial y^2} \qquad (1)$$

The Laplacian is a 2-D isotropic measure of the second spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is usually combined with smoothing as a precursor to finding edges via zero-crossings.

The 2-D Gaussian function is

$$h(x,y) = -e^{-\frac{x^2+y^2}{2\sigma^2}} \qquad (2)$$

Where σ is the standard deviation, blurs the image with the degree of blurring being determined by the value of σ.

The laplacian of h is as follows:

$$\nabla^2 h(x,y) = -\left[\frac{x^2+y^2-2\sigma^2}{\sigma^4}\right] e^{-\frac{r^2}{2\sigma^2}} \qquad (3)$$

III. Sobel Edge Detection

Sobel edge detector computes the partial derivatives in gradient which may be approximated in digital images. Typically it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image. The sobel edge detection technique is based on horizontal and vertical convolution of the image. Sobel edge detector is very sensitive to noise[8].

The sobel edge detector consists of pair of 3×3 convolution kernels as shown in the fig.1. In sobel edge detector, one kernel is rotated the other by 90°.

-1	0	+1
-2	0	+2
-1	0	+1

G_x

+1	+2	+1
0	0	0
-1	-2	-1

G_y

Fig.1 masks used by the sobel operator

These two kernels can be applied individually to the input image. It produces separate measurements of the gradient component in each orientation. These two kernals are denoted by G_x and G_y. These can be combined together to find the absolute magnitude of the gradient at each point and also the orientation of that gradient.

The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2} \qquad (4)$$

An approximate magnitude is given by:

$$|G| = |G_x| + |G_y| \qquad (5)$$

IV. SIMULATION RESULTS

This section presents the simulation results which are conducted to examine the performance of the sobel edge detector. This is done by using Matlab 7.8.0(R2009a). Edge detection using sobel edge detector is performed on the face is shown in the fig.2 as shown below. It has been shown gradient in x and y directions of the original image i.e. G_x and G_y and gradient of combination of both i.e. $G_x + G_y$.

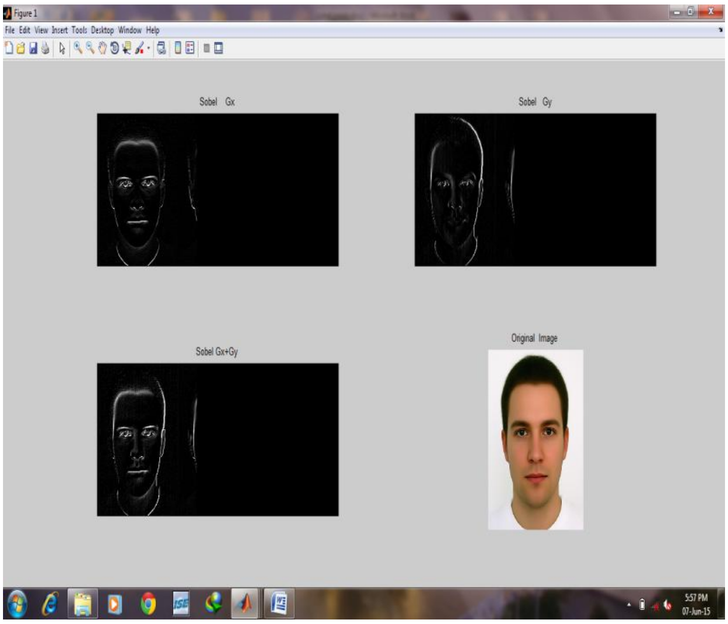

Fig.2 Results of Sobel Edge Detection

V.CONCLUSION

Since Edge detection is one of the most important techniques that have been commonly implemented in image processing. It is used in image

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segmentation, registration and identification of image processing. In this paper, we have studied Sobel edge detection technique that uses first derivative with simpler calculations to detect edges. . It has been shown gradient in x and y directions of the original image i.e. G_x and G_y and gradient of combination of both i.e. G_x+ $G_{y.}$ It has also been shown that it is a single stage process for detection of edges and easy to implement.

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